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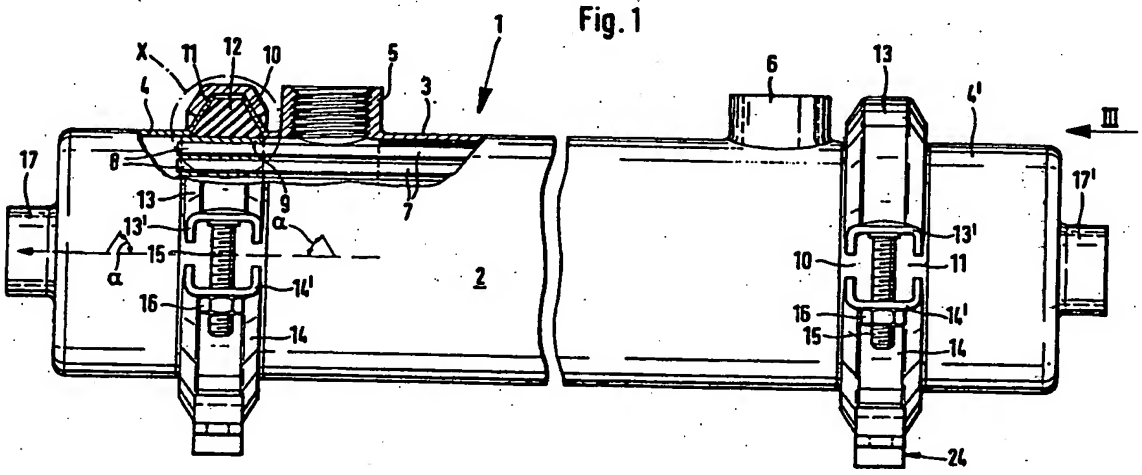
GB 1370617 GB 1206985 GB 0734008
GB 1363241 GB 1112265 GB 0557926
GB 1300162 GB 0804359

(58) Field of search
F4S
F2B

(54) Heat exchanger

(57) A heat exchanger has a housing (2) in which a first heat exchange fluid flows through tubes (7), extending between tube plates (9) which are held movably within the limits of thermal expansion in metal end portions (4, 4', 27), braced to metal tubular shell (3) for the flow of a second heat exchange fluid through the shell *via* inlet and outlet connections (5, 6), the end portions (4, 4', 27) and the tubular shell (3) having, at their opposite ends, outwardly directed bent-over edges (10, 11, 28, 29), wherein the angle α relative to the longitudinal axis is between 45° and 90°. A sealing ring (12, 30) seals of each end tube plate (9) both with respect to the tubular shell (3) and to the end portion (4, 4', 27) and is gripped between two oppositely disposed bent-over edges (10, 11 and 28, 29), clamped together by clips (13, 14, 31).

Fig. 1



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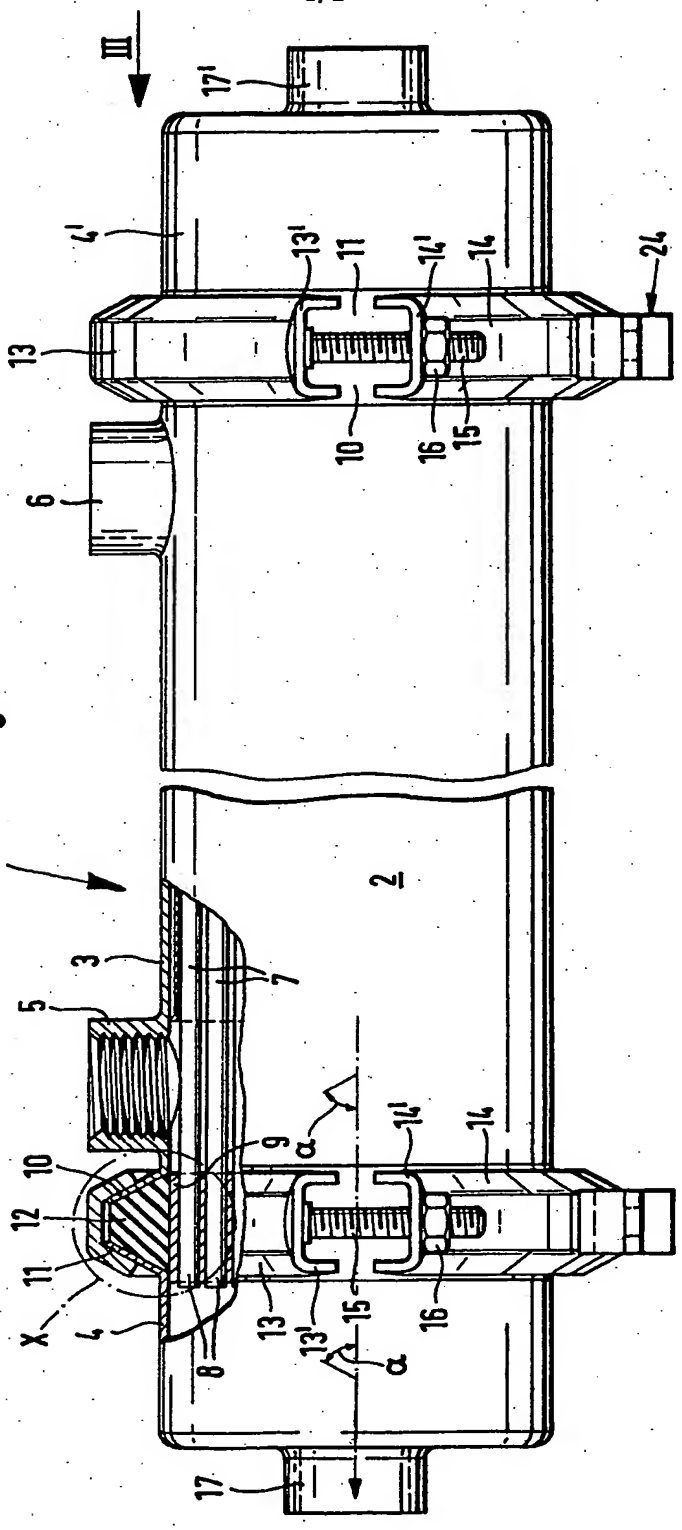


Fig.1

Fig. 2

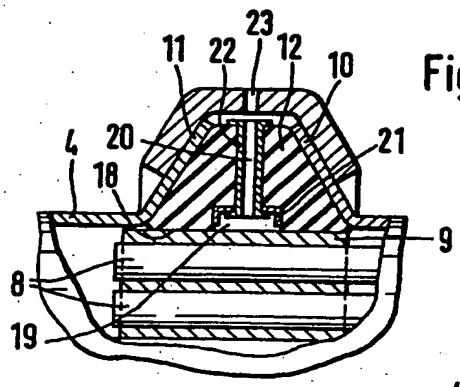


Fig. 3

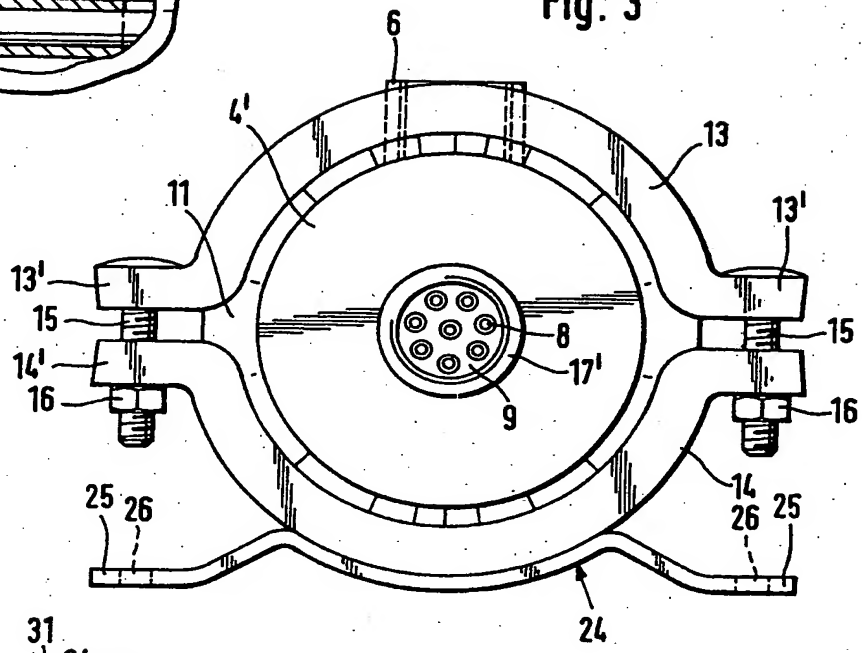


Fig. 4a

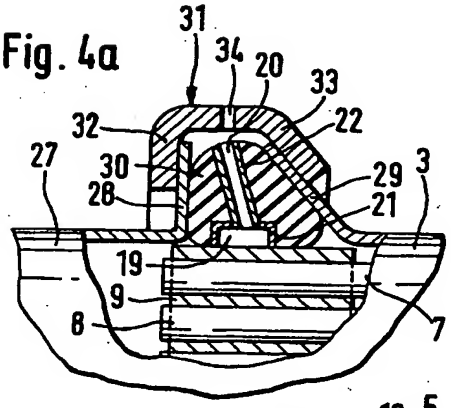


Fig. 4b

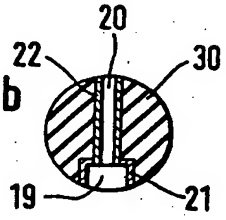
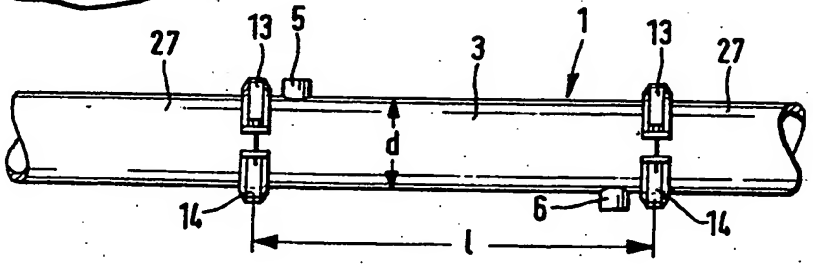


Fig. 5



SPECIFICATION

Heat exchanger

This invention relates to a heat exchanger having a nest of tubes in a housing.

German laid-open application (DE-OS) No 31 10 489 already discloses a heat exchanger comprising a housing and a nest of tubes disposed therein. The ends of the heat exchanger tubes are mounted in tube plates at the ends and have a first heat exchange medium flowing therethrough. The housing comprises a metal tubular shell, two housing rings and two covers which are braced to each other by tie members and nuts. The tube plates are held in the covers and the housing rings, with the interposition of sealing rings, in such a way that they are movable within the limits of thermal expansion. The housing rings have inlet and outlet connections for a second heat exchange medium which flows around the outside of the heat exchanger tubes, within the tubular shell.

Such a proposed heat exchanger is very expensive in construction as a large number of individual components with cost-intensive machining operations, as well as a high level of assembly expenditure are necessary. For example, the housing includes five individual parts which, including the commercially available tubular shell, must be machined after cutting to length as otherwise it would not be possible to ensure that the components bear properly against each other, in particular at the flange-type connection between the tubular shell and the housing rings. In addition, the proposed arrangement requires a plurality of sealing rings for the parts of the housing to be sealed off relative to each other and relative to the tube plates and to separate the fluid circuits from each other.

US patent specification No 3 426 841 discloses a tube nest-type heat exchanger in which plastics tubes are held in a tube plate which also comprises plastics material. The housing also consists of plastics components, including a tubular central portion with covers at the ends thereof. The tubular central portion and the covers have flange-like shoulders at their ends, with the edge of a tube plate extending between each two oppositely disposed shoulders. A respective sealing ring is disposed between each shoulder and the tube plate. The housing components are secured in position by means of clamping rings in such a way that the flanges are pressed against the tube plates. Thermal expansion of the tube nest must be accommodated by way of the elasticity of the tube plates.

Although the latter proposed heat exchanger is of simple construction, by virtue of the configuration of the housing portions and the fixing means, it does however suffer from the disadvantage that it consists entirely of plastics components. The choice of plastics materials used is such that they can be fused together so that it is possible to fuse the outer edge of the tube plate to the flange-like shoulders. Quite apart from the fact that heat exchangers of metal materials are required for a large number of situations of use, where it is not possible to use plastics materials, there is a further problem that the known arrangement can only be constructed with relatively elastic tube plates. It is not possible to use a tube neat with rigid tube plates which are limitedly displaceable in the housing. Finally, such a known heat exchanger must be produced with low tolerances as the mutually oppositely disposed surfaces of the flange-like shoulders and the interposed edge of the tube plate extend virtually parallel and thus it is not possible to compensate for tolerance differences by further tightening the clamping clips.

There is thus a need for a generally improved heat exchanger having a nest of tubes in a housing, which heat exchanger comprises simple shape components which can be produced inexpensively, has a high degree of compensation for tolerance differences, and is extremely simple to assemble.

According to the present invention there is provided a heat exchanger having a nest of tubes in a housing which tubes are held in tube plates located at the ends of the tubes, for the flow of a first heat exchange fluid through the tubes, wherein the housing includes a metal tubular shell and two metal end portions and the tube plates are held movably within the limits of thermal expansion in the end portions, with the interposition of sealing rings, the end portions being braced to the tubular shell which is disposed therebetween for the flow of a second heat exchange fluid through the tubular shell and which has inlet and outlet connections for the second heat exchange fluid, wherein the end portions and the tubular shell are provided at their oppositely disposed ends with outwardly directed bent-over edges, wherein the angle (α)relative to the longitudinal axis of the tubular shell and the end portions is at least 45° and at most 90°, wherein provided at each tube plate is a sealing ring which seals off the tube plate both with respect to the tubular shell and also with respect to the end portion and which at the same time is gripped between two mutually oppositely disposed bent-over edges, and wherein there are provided clamping clips which engage over the bent-over edges, the form of the clamping rings corresponding to that of the mutually oppositely disposed bent-over edges of the end portions and tubular shell.

A heat exchanger of the invention has an extremely low number of individual components, which can be produced with relatively large tolerances and do not require any finishing machining operations. The sealing rings

serve to seal the tube plate relative to both housing portions which are to be clamped together, and at the same time serve to compensate for production tplerances and variations in length. By the shape of the clamping means, a heat exchanger of the present invention in a simple fashion, provides the possibility of re-tightening up the components, while further screwing the clamping clips together provides for a clear longitudinal displacement of the housing portions towards each. In addition, the sealing arrangement provides for considerable displacement as a result of thermal expansion without the precise sealing effect being lost when that occurs.

Preferably the angles of two mutually oppositely disposed bent over edges are of equal magnitude and are about 60° with respect to the longitudinal axis of the housing. This symmetrical cross-sectional shape of the connecting arrangement means that the clamping clip is also of a symmetrical cross-section and thus there cannot be any confusion of sides in the assembly operation. Depending on the arrangement of the heat exchanger however it may be advantageous for, for example, the end portions to have an approximately right-angled edge and for the edge of the housing which is in opposite relationship thereto to be arranged at an angle of $\leqq 60°$. The clamping clip must then be of a suitably corresponding shape, although relative displacement when the clamping clips are tightened is ensured by virtue of the edge which is at a smaller angle. An arrangement of this kind is particularly suitable when the tube nest, with the tubular shell, is to be introduced between fixedly mounted end portions and the tube plates may only slightly project into the end portions.

Advantageously the heat exchanger includes a leakage indicator means. To this end each sealing ring, at its surface which in use is directed towards the associted tube plate, has a groove extending in the peripheral direction of the tube plate and which communicates with the outside of the heat exchanger by at least one radial passage in the sealing ring. By virtue of such leakage indication, which can advantageously be integrated into the sealing ring, in the event of a leak between the tube plate and the tubular shell or between the tube plate and the end portion, the escaping fluid is conducted to the exterior of the heat exchanger and is prevented from getting into the other heat exchange fluid. This avoids damage which would be caused by mixing of different fluids. The presence of fluid on the heat exchanger exterior indicates that there is a leak. So that the fluid leakage flow cannot issue only at the connecting locations of the clamping clips, it is advantageous for the clamping clip to have radial openings whose cross-section corresponds at least to that of the radial passages in the seal. In order also to ensure that there is a duct for any fluid leakage flow which may occur when clamping the housing portions by the clamping clip and with the consequential deformation of the sealing ring, it is possible for the groove to be formed by a stiff insert and the radial passage to be in the form of an inherently stable tube.

In a preferred embodiment the sealing ring has a cross-sectional shape which corresponds to a trapezium whose base surface bears in use against the tube plate and whose side surfaces bear in use against the bent-over edges of the housing portions. This arrangement ensures that the sealing ring is in contact with the respective sealing surfaces over a large area, irrespective of the degree to which the clamping clip is tightened. Such an arrangement is particularly recommended when the angles of two mutually oppositely disposed bent over edges are equal.

If the angles of two mutually oppositely disposed bent-over edges are different, then desirbly the sealing ring may have a round cross-section. Such a sealing ring can easily match itself to any shape.

Conveniently a respective one of two mutually associated clamping clips is provided with bars or a bracket or loop for securing the heat exchanger to a surface. In this way, there is no need for separate fixing means or for the mounting thereof on the housing of the heat exchanger. The tubular shell is particularly simple and cost-effective to produce if it is a drawn tubular body with inlet and outlet connecting members formed out of the body, for the second heat exchange fluid.

Covers with inlet and outlet connections for the first heat exchange fluid may be provided in known manner as end portions of the housing. However, it is also possible for the end portions of the housing to be formed by connecting tubes which are of the same diameter as the tubular shell. A particular advantage of this arrangement is achieved when the connecting tubes are formed by tubes of a conduit system, which are present in any case, thereby saving on additional covers and connections for the first heat exchange fluid.

For a better understanding of the present invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a partly sectioned view of a tube nest heat exchanger with clamping clip connection according to one embodiment of the invention,

Figure 2 is a sectional view on an enlarged scale of an alternative construction of the detail X of Figure 1,

Figure 3 is an end view taken along line III in Figure 1,

Figure 4a is a sectional view of an alternative form of construction to that shown in Figure 2,

Figure 4b is a cross sectional view of a

sealing ring of round cross-section in the unclamped condition, and

Figure 5 is a side view of a heat exchanger of the invention in an existing conduit system.

In Figure 1 of the accompanying drawings is shown a heat exchanger 1 of the invention having a housing 2. The housing 2 includes a metal tubular shell 3 and two metal end portions which are formed as covers 4 and 4'. The tubular shell 3 has two connections 5 and 6 forming an inlet 5 and an outlet for a second heat exchange fluid to flow through the housing. As shown by the partly sectioned view on the left-hand side in Figure 1, disposed in the tubular shell 2 is a nest of tubes 7, with ends 8 of the tubes 7 being held in and between two spaced rigid tube plates 9.

At each end, the tubular shell 3 has an outwardly directed bent-over edge 10, the angle α between the edge 10 and the longitudinal axis of the heat exchanger being about 60°. At its side which is towards the tubular shell 3, the cover 4 also has an outwardly directed bent-over edge 11 which, like the edge 10 of the tubular shell 3, is at an angle α of about 60° with respect to the longitudinal axis of the heat exchanger 1. Disposed between the two bent-over edges 10 and 11 is a sealing ring 12 which is of a trapezoidal cross-section. The sealing ring 12 bears with its inward peripheral surface, that is to say, the base of the trapezium, against the outer periphery of the tube plate 9 and bears with its side surfaces against the bent-over edges 10 and 11 and thus simultaneously seals the tube plate 9 with respect to the tubular shell 3 and the cover 4.

An identical arrangement of bent-over edges 10 and 11 and the seal 12 is to be found at the other end of the tubular shell 3, namely where the cover 4' is connected to the tubular shell 3. For the purposes of securing the covers 4 and 4' to the tubular shell 3, the arrangement has clamping clips 13 and 14 whose cross-sectional shape corresponds to that of the bent-over edges 10 and 11. Two associated clamping clips 13 and 14 engage over the bent-over edges 10 and 11 as well as over the sealing ring 12 disposed therebetween, virtually over the entire periphery thereof, and can be tightened by means of screws 15 and nuts 16 which engage bars 13' and 14' on the clamping clips 13 and 14. The further the nuts 16 are screwed on to the screws 15, the greater is the degree to which the clamping clips 13 and 14 move downwardly on to the bent-over edges 10 and 11 and, by virtue of the inclined surfaces, cause the covers 4 and 4' to be moved towards the tubular shell 3. At the same time, this increases the pressure force acting on the sealing ring 12. As can also be seen from Figure 1, inlet and outlet connections 17 and 17' for the first heat exchange fluid are provided at the ends of the exchanger on the covers 4 and 4'.

Figure 2 shows an alternative form of the detail indicated at X in Figure 1, on an enlarged scale. Just as in Figure 1, this heat exchanger has two bent-over edges 10 and 11 which are disposed in opposite relationship to each other and which have the same angle(α) relative to the longitudinal axis of the heat exchanger. Disposed between the edges 10 and 11 is the sealing ring 12 of trapezoidal cross-section. At the surface 18 which is towards the tube plate 9, the sealing ring 12 has a groove 19 which extends in the peripheral direction and which communicates with the exterior of the sealing ring 12 by a passage 20 extending in the radial direction. Thus, the sealing ring 12 has two sealing portions at the surface 18, those two portions acting like separate seals. Specifically, if a leak occurs at one of the sealing portions, the escaping heat exchange fluid is conducted outwardly through the groove 19 and the radial passage 20 and cannot therefore pass into the other heat exchange fluid, which in some cases would result in serious damage.

As sealing rings 12 of that kind conventionally are made of rubber-elastic materials a stiff insert 21 is provided in order to maintain the shape of the groove 19. The radial passage 20 is formed by an inherently stable tube 22. So that any leakage flow which may occur can issue not only at the ends of the clips 13 and 14, which are formed by the bars 13' and 14', which may be disadvantageous depending on the particular position of the heat exchanger, the clamping clips 13 and 14 also have radial openings 23 so that any leakage can be very rapidly detected, when fluid issues.

Figure 3 shows a view taken along line III-III in Figure 1, with the reference numerals from Figure 1 being used to denote the same components. Figure 3 illustrates the cover 4' with the edge 11 which is of larger radius, and the tubular connecting member 17 through which it is possible to see a portion of the tube plate 9 with ends 8 of the tubes secured therein. The tube clips 13 and 14 each engage over almost half the periphery of the edge 11 so that between the radially outwardly directed bars 13' and 14', there is still sufficient space for tightening the clips together by means of screws 15 and nuts 16. Welded to the lower clamping clip 14 is a bracket or loop 24 which is provided with fixing holes 26 at its projecting ends 25 so that the bracket 24 can be used for securing the heat exchanger to a surface.

Figure 4a shows an alternative construction of the connecting arrangement wherein the end portion of the heat exchanger is formed by a tube 27 of a conduit system which is of the same diameter as the tubular shell 3. The connecting tube 27 has an edge 28 which is directed outwardly substantially at a right

angle while disposed in opposite relationship therewith is a bent-over edge 29 of the tubular shell 3. The edge 29, with respect to the longitudinal axis of the heat exchanger, is at an angle α of about 50°. Disposed between the bent-over edges 28 and 29 and the tube plate 9 in which the tube ends 8 are secured is a sealing ring 30 which bears against the periphery of the tube plate 9 and the bent-over edges 28 and 29. The sealing ring 30 is originally of a round cross-section, as can be seen from Figure 4b; however, by virtue of its elasticity and the forces acting thereon, when the bent-over edges 28 and 29 are tightened together, the sealing ring 30 is deformed in such a way that it bears over a large area both against the bent-over edges and against the tube plate 9. Like the sealing ring 12 already described with reference to Figure 2, the sealing ring 30 has a peripheral groove 19 with reinforcing insert 21 and a tube 22 forming the radial passage. To correspond to the angles of the edges 28 and 29, the assembly includes a clamping clip 31 whose limb portions 32 and 33 are adapated to the angles of the edges 28 and 29. In addition, the clamping clip 31 has a radial opening 34 for leakage fluid to pass therethrough. In the connecting arrangement shown in Figure 4a, when the clip 31 is tightened, the connecting tube 27 and the tubular shell 3 are displaced towards each other only by virtue of the inclined surfaces of the edge 29 and the limb portion 32.

Figure 5 is a diagrammatic view of use of the heat exchanger according to the invention in an existing conduit system. Reference numeral 27 denotes the connecting tubes which are of the same diameter as the tubular shell 3 of the heat exchanger 1. The heat exchanger 1 is connected to the connecting tubes 27 by means of clamping clips 13 and 14 in the same fashion as described in detail with reference to Figure 1. As can be clearly seen from Figue 5, in that way it is possible to eliminate the covers serving as end portions, as shown in Figure 1, and the corresponding tubular connecting members for the first heat exchange fluid. Use of the heat exchanger in that fashion is possible only because the connecting arrangement permits substantial compensation for tolerance differences, while the two heat exchange medium flow circuits are reliably sealed off from each other.

CLAIMS

1. A heat exchanger having a nest of tubes in a housing which tubes are held in tube plates located at the ends of the tubes, for the flow of a first heat exchange fluid through the tubes, wherein the housing includes a metal tubular shell and two metal end portions and the tube plates are held movably within the limits of thermal expansion in the end portions, with the interposition of sealing rings, the end portions being braced to the tubular shell which is disposed therebetween for the flow of a second heat exchange fluid through the tubular shell and which has inlet and outlet connections for the second heat exchange fluid, wherein the end portions and the tubular shell are provided at their oppositely disposed ends with outwardly directed bent-over edges, wherein the angle(α)relative to the longitudinal axis of the tubular shell and the end portions is at least 45° and at most 90°, wherein provided at each tube plate is a sealing ring which seals off the tube plate both with respect to the tubular shell and also with respect to the end portion and which at the same time is gripped between two mutually oppositely disposed bent-over edges, and wherein there are provided clamping clips which engage over the bent-over edges, the form of the clamping rings corresponding to that of the mutually oppositely disposed bent-over edges of the end portions and tubular shell.

2. A heat exchanger according to claim 1, wherein the angles (α)of two mutually oppositely disposed bent over edges are of equal magnitude and are about 60°.

3. A heat exchanger according to claim 1, wherein the angles of two mutually oppositely disposed bent over edges are different, wherein one edge has approximately an angle of 90° and the other edge has an angle of $\leq$60°.

4. A heat exchanger according to any one of the preceding claims, wherein at its surfce which in use is directed towards the associated tube plate, each sealing ring has a groove which extends in the peripheral direction of the tube plate and which communicates with the outside of the heat exchanger by at least one radial passage in the sealing ring.

5. A heat exchanger according to claim 4, wherein each clamping clip has radial openings whose cross-section corresponds at least to that of the radial passages in the associated sealing ring.

6. A heat exchanger according to claim 4, wherein the groove is formed by a stiff insert and the radial passage is in the form of an inherently stable tube.

7. A heat exchanger according to any one of the preceding claims, wherein the sealing ring has a cross-sectional configuration of a trapezium whose base surface bears in use against the tube plate and whose side surfaces bear in use against the bent over edges.

8. A heat exchanger according to any one of claims 1 to 6, wherein the sealing ring has a round cross-section.

9. A heat exchanger according to any one of the preceding claims, wherein a respective one of two mutually associated clamping clips is provided with bars or a bracket for securing the heat exchanger to a surface.

10. A heat exchanger according to any one of the preceding claims, wherein the tubular shell is a drawn tubular body with inlet and outlet connecting members, formed out of the body, for the second heat exchange fluid.

11. A heat exchanger according to any one of the preceding claims, wherein the end portions of the housing are in the form of covers having inlet and outlet connections for the first heat exchange fluid.

12. A heat exchanger according to any one of claims 1 to 10, wherein the end portions of the housing are formed by connecting tubes of the same diameter as the housing.

13. A heat exchanger having a nest of tubes in a housing, substantially as hereinbefore described with reference to Figures 1 and 3, Figure 2, Figure 4a, Figure 4b or Figure 5 of the accompanying drawings.

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